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Special Report 77-33
October 1977

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LAND TREATMENT OF WASTEWATER at West Dover, Vermont

John R. Bouzoun

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Special Report 77-33	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LAND TREATMENT OF WASTEWATER AT WEST DOVER, VERMONT.		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John R. Bouzoun		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Directorate of Civil Works Office, Chief of Engineers Washington, D.C. 20314		12. REPORT DATE October 1977
		13. NUMBER OF PAGES 31
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) CRREL-SR-77-33		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

(9) (6) (10) (11) (14) (12) 32p.

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Cold regions	Sewage treatment
Facilities	Spray irrigation
Land treatment	Wastewater

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A general description of a wastewater land treatment system located in a "cold temperate" climatic region is given. The winter season average daily design flow is almost double that of the summer-fall season (0.55 MGD vs 0.30 MGD). Wastewater is sprayed on a forested knoll after it receives secondary biological treatment. The system is operated during the winter when the ambient air temperature is as low as 10°F (−12.2°C). Spray nozzles have been developed that ensure rapid drainage of the spray laterals after each spray cycle and, therefore, prevent their freezing.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

This report was prepared by John R. Bouzoun, Research Sanitary Engineer, of the Research Division, U.S. Army Cold Regions Research and Engineering Laboratory. The study was funded by Corps of Engineers Civil Works Project CWIS 31280, *Evaluation of Existing Facilities for Wastewater Land Treatment.*

Technical reviewers of the manuscript were Dr. E. Alan Cassell, Director of the Vermont Water Resources Research Center and his associate Donald Meals, and Robert Sletten of CRREL.

The author would like to express his appreciation to Dr. Cassell and Mr. Meals for their excellent work in preparing Reference 1, which served as the basis for this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Conversion Factors

Multiply	By	To Obtain
Inches	2.54	centimeters
Feet	0.3048	metres
Gallons	0.003785412	cubic metres
Million gallons per day	0.04381264	cubic metres per second
Cubic feet per second	0.02831685	cubic metres per second
Acres	0.4046873	hectares
Pounds	0.4535924	kilograms
Degrees Farenheit (°F)	(°F-32)/1.8	degrees Celsius

SUMMARY

The land treatment system at West Dover has been designed to treat a winter average daily flow of 0.55 million gallons. After two winters of operation, several problems relating to freezing of the spray nozzles and laterals were corrected so that spraying could continue throughout the winter season. Spray application of effluent is possible at this site when the ambient temperature is as low as 10°F.

At the present time, water quality samples from the effluent being sprayed, the groundwater wells, the flow in the diversion ditch, and both the North Branch of the Deerfield River and Ellis Brook are being collected for CRREL by the Vermont Water Resources Research Center. The results from this sampling program will be published in subsequent reports. The possibility of using special equipment to make snow from the secondary effluent is also being investigated. The snow will form an insulating blanket on the ground and reduce the amount of soil that freezes. This will ensure that infiltration of water into the soil continues throughout the winter, reducing the amount of runoff experienced during the spring melt.

INTRODUCTION

Using the land as a disposal site for human and animal wastes is certainly not a new concept; however, using the land to treat wastewater has only recently been recognized as an effective method of providing advanced treatment to wastewater. Land treatment of wastewater became a viable method of waste treatment when the "zero discharge of pollutants" goal of Public Law 92-500 was enacted. At this time CRREL formed an interdisciplinary team of engineers and scientists to conduct research in land treatment of wastewater.

Since wastewater has been applied to agricultural lands throughout the United States, CRREL initiated a project to visit existing land treatment sites and (1) assess the long-term effects of applying wastewater to the land by determining the chemical and physical changes that have taken place in the plants, the soil, and the groundwater, (2) observe the design and operation of these systems, (3) disseminate the information to engineers and scientists who design, construct, and operate land treatment systems. This report is a discussion of the design and operation of a new land treatment system located in southern Vermont. It is intended to serve as an interim summary of findings at the West Dover, Vermont, land treatment facility and includes a description of the facility, data obtained to date, and a discussion of problems and solutions encountered at the site.

GENERAL

The treatment facility that serves North Branch Fire District Number 1, in the Township of Dover, Vermont, is about 14 miles north of the Vermont-Massachusetts state line, south-southeast of the village of West Dover (Fig. 1). The treatment facility encompasses about 80 acres and is bounded on the west by the North Branch of the Deerfield River and on the east by Ellis Brook. The maximum elevation at the site is 1717 ft above sea level and the minimum elevation is approximately 1600 ft.[1]

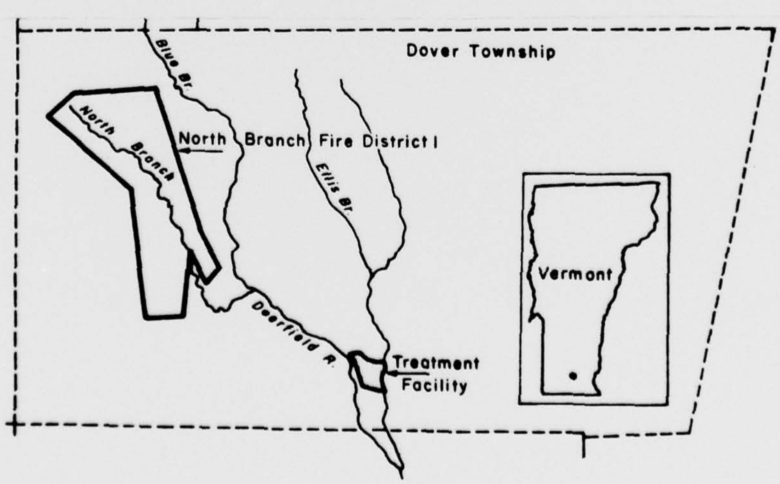

Figure 1. General location map.

The climate of the region is classified as "cold temperate." The mean annual temperature of the Dover region is about 43°F. Average annual precipitation is about 55 in. and snowfall ranges in excess of 100 in. annually. On the average the area has about 120 days with snow cover per year and a frost-free period of about 90 days.[1]

When a treatment plant was proposed for West Dover in 1972, high level treatment alternatives needed to be considered because on 27 May 1971 the Vermont Water Resources Board had adopted strict water quality controls. Rule 10 of these "Regulations Governing Water Classification and Control of Quality" establishes controls on discharges to "upland streams" and "pristine streams." "Upland streams" are defined as all those stretches upstream of the most upstream discharge of wastes from an existing municipal treatment plant or upstream of a community sewer discharging wastes requiring treatment in a manner to be approved by the Department of Water Resources. "Pristine streams" are defined as those stretches of upland streams which flow above 1500 ft elevation, or have a 7-day low flow (10 year return) of less than 1.5 cfs. Discharges which may degrade, in any respect, the quality of the receiving water, are not permitted to enter pristine streams.[2]

The North Branch of the Deerfield River is pristine at all points above the municipal treatment plant in the Village of Wilmington due to elevation. Therefore, no discharge is allowed to Ellis Brook or the North Branch of the Deerfield River in the West Dover area, and off-stream disposal is necessary at the West Dover site. An alternative would have been to pipe the wastewater downstream of the existing Wilmington municipal discharge. The engineering firm retained by the North Branch Fire District Number 1 studied this alternative as well as land treatment and groundwater recharge alternatives, and concluded that land treatment was the most economically attractive.[3]

DESIGN

The population of the district to be served by the system was very difficult to estimate because of the recreation industry in the area. The West Dover area presently includes two major ski areas with related lodging and restaurants. There are also many private recreational and permanent residences in this area, which are also used primarily during the ski season. Also there are significant differences between the weekday and weekend/holiday population. Due to the recreational activities in the district, the engineering firm working for the district divided the population into three classifications: commercial and transient people; overnight staff and guests; and residential. The design populations for the years 1972 and 1992 are summarized in the following table (Table I).

Table I[3]. Design population by category.

Year	Commercial and transient	Overnight staff and guests	Residential
1972	13,050	3,230	2,360
1992±	13,050	3,230	5,310*

*Projected 1992± residential population is based on an increase of 125% of present residential population.

The following table (Table II) shows the design unit flows.

Table II[3]. Design unit flows.

	(gallons per capita per day)
Commercial & transient	10
Overnight staff & guests	80
Residential	80

The computed wastewater flows, the five-day biochemical oxygen demand (BOD) and suspended solids loading are broken down into winter, spring, summer and fall to indicate the anticipated seasonal variations (Table III).

The wastewater generated throughout the district is pumped from the final collection point on Route 100 to the treatment facility. This facility provides biological stabilization prior to spray irrigation. Figure 2 is a hydraulic schematic of the entire facility.

TABLE III[3]. Design loadings summary.

	Initial (1974)	Design (1992)
Design Loadings		
Population Equivalent		
Winter Maximum Day	7,250	10,250
Flows (MGD)		
Winter Season (121 days)		
Average Daily Flow	0.35	0.55
Maximum Daily Flow	0.58	0.82
Peak Flow, maximum hour	2.04	2.84
Spring Season (61 days)		
Average Daily Flow	0.07	0.11
Maximum Daily Flow	0.21	0.48
Peak Flow, maximum hour	0.38	0.85
Summer-Fall Season (183 days)		
Average Daily Flow	0.17	0.30
Maximum Daily Flow	0.32	0.78
Peak Flow, maximum hour	0.59	1.38
Suspended Solids		
Primary Influent mg/l	300	300
lb/day, average day		
Winter Season	880	1,380
Spring Season	175	425
Summer-Fall Season	275	750
lb/day, Winter maximum day	1,460	2,050
Biochemical Oxygen Demand		
Primary Influent mg/l	255	255
BOD Loading, lb/day, average day		
Winter Season	740	1,170
Spring Season	150	360
Summer-Fall Season	235	635
BOD Loading, lb/day		
Winter maximum day	1,205	1,745

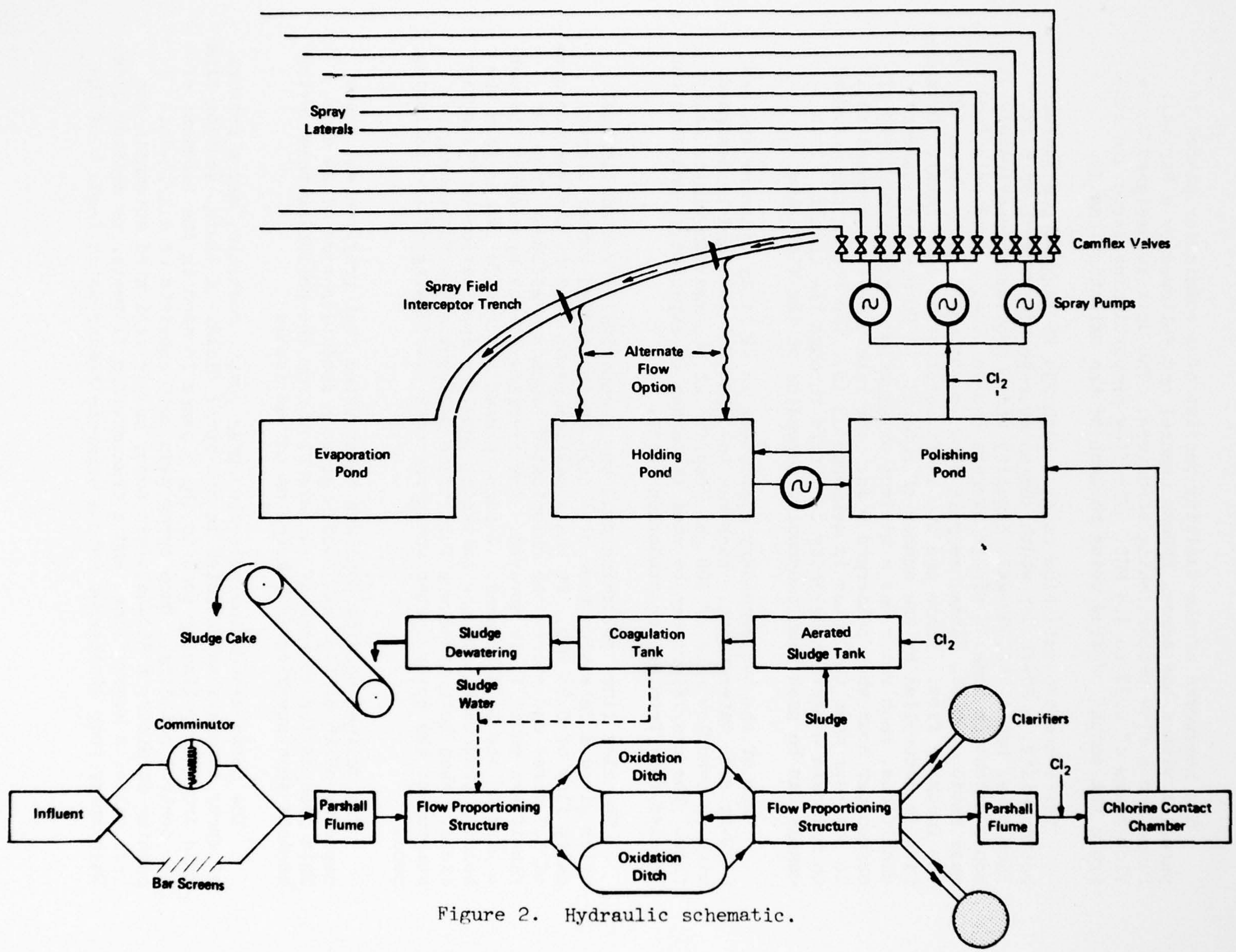

Figure 2. Hydraulic schematic.

The headworks of the facility consist of a comminutor placed in parallel with a bar screen bypass channel and followed by a Parshall Flume and a flow proportioning structure. The unit is designed for a flow range of 0.35 to 3.5 MGD. The flow proportioning structure controls the amount of flow going to each of the oxidation canals.

There are two oxidation canals, each 254 ft long with a 14-foot bottom width, a 28-ft top width and an average water depth of 6 ft. Each canal has a 442,000-gal. capacity which provides approximately 24 hours detention time at winter average design flow. Based on a food to mass ratio of 0.06, normal recycle flow is estimated to be about 40% of the incoming flow. There are two 14-ft aerators in each canal. Oxygenation is controlled by the number of rotors. At 90 RPM and standard conditions, each rotor has a minimum oxygenation capacity of 50 lb of oxygen per hour when submerged 9 in. The rate this is decreased to 17 lb per hour when the rotor is submerged 3 in. The rotors are designed to maintain a minimum velocity of 1 ft/s through the canals. Both canals can be used simultaneously, depending on the flow rate.

Each of the two secondary clarifiers is 42 ft in diameter and has a 10-ft side water depth. Each can hold 104,000 gal. and is designed with an overflow rate of 300 gal./day/ft^2 at the maximum winter daily flow. The clarifiers can be used in tandem or separately, and each can receive flow from either oxidation canal.

The clay lined polishing pond has a capacity of 2.2 million gal. which gives a detention time of 4 days at the design winter average daily flow of 0.55 MGD. It has a maximum depth of 5 ft and surface area of 1.7 acres and stores the chlorinated secondary effluent from the clarifiers until it is sprayed. Any overflow passes by gravity through a pipe to the holding pond. A pump is used to transfer water from the holding pond back into the polishing pond for application to the spray field. When both ponds are full there are provisions for automatic startup of the spray system which prevents overflowing of the polishing pond.

The unlined holding pond was constructed over fragipan and has a capacity of 16 million gal. which gives a detention time of 29 days. This pond is for storage of the overflow from the polishing pond during periods when spraying is limited or not advisable.

The spray system includes the spray pumps, controls, and a network of spray laterals and nozzles in the spray field. A 12-in. suction line runs from the polishing pond to the 3 pumps located in the basement of the control building. Each spray pump unit consists of a 1/16-in. opening strainer, a 350-gal./min pump, an air activated automatic control valve, a bypass line, and a transmitting flowmeter to monitor flow. Each spray pump discharges into a separate header which feeds 4 of the

spray laterals on the spray field. Each spray header has an adjustable, automatically controlled Camflex spray valve with an accompanying automatically controlled header drain valve. The drain manifold is piped back into the polishing pond. All header lines run underground from the control building and through the center access trail of the spray site. Four spray laterals extend from each header in a north-south direction. The 12 spray laterals run parallel to each other, 75 ft apart, and follow the undulating contours of the spray site. Figure 3 is a profile view of a typical spray lateral. The spray laterals are suspended 5 to 15 ft above the ground and consist of 2- and 3-in. galvanized steel pipe insulated by a jacket of PVC pipe. Vegetation is cleared 5 to 10 ft from either side of each lateral. There are 66 low points in the system where 3/4-in. spray nozzles have been installed. These nozzles spray downwards and rapidly drain the laterals after each spray cycle. Two types of nozzles that spray upwards have been used at 50- and 25-ft centers on the rest of each spray lateral depending on the season. Additional information on the spray nozzles and their operating characteristics will be presented later in this report.

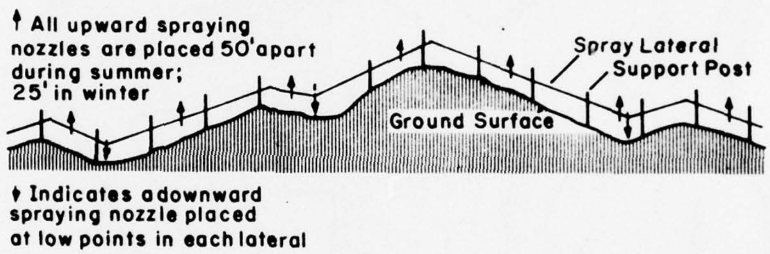

Figure 3. Cross section of a typical spray lateral (not to scale).

There are approximately 34 acres of actual spray area covered by the laterals. A 200-ft buffer zone separates the spray area from the perimeter of the spray site, bringing the total area of the spray site to approximately 50 acres.

The 3 spray pumps and 12 Camflex spray valves can be automatically or manually controlled from the operation panel. A cam/timer system can be used to program the desired timing and selection of spray laterals. Under normal operation the spray system is divided in 3 sections, each consisting of one spray pump and four laterals. At any given time each pump will distribute water to one lateral in a section. The flow to each lateral is determined by the number of nozzles on the lateral, the desired application rate, and the spray schedule. The pump flowmeter indicates the flow rate which is controlled by adjustment of the Camflex valve. The cam/timer is used to alternate between each lateral in the section and to control the amount of time each lateral is in use.

The spray site is located on a knoll west of the plant. This knoll is about 1700 ft in elevation and about 2000 ft long and rises 100 ft above the plant site. The eastern side of this knoll slopes at an average of 8-15% toward the plant site. The western side slopes even more steeply (25%) and extends into a Pleistocene valley cut by the North Branch of the Deerfield River. Figure 4 shows the relative position of the various unit processes at the facility.

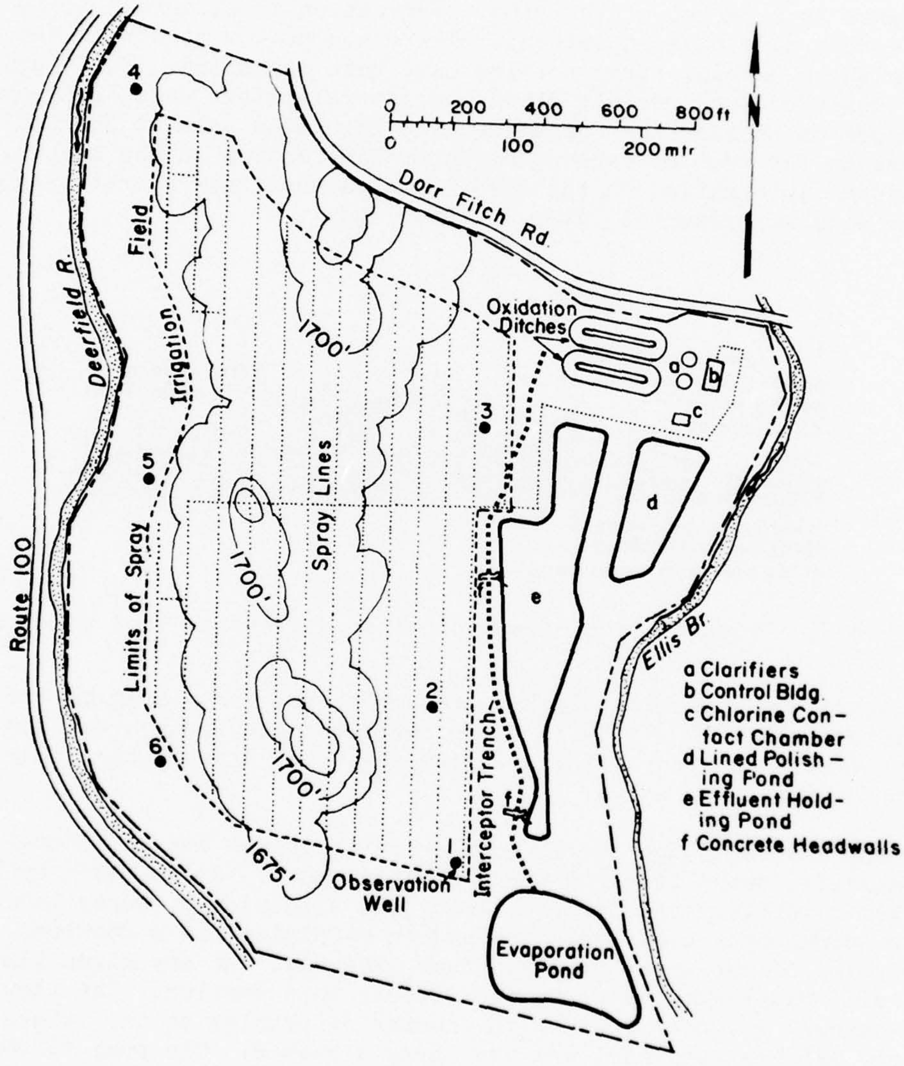

Figure 4. Relative position of various unit processes.

The spray field interceptor trench that was placed in the underlying fragipan runs southerly along the eastern perimeter of the spray field to the evaporation pond. The purpose of the interceptor trench is to prevent spray field runoff from entering the holding pond, which under certain weather conditions can result in repeated pumping and spraying of the same water. Groundwater and surface runoff from the easterly sloping portion of the spray field is collected in the interceptor trench and flows by gravity to the evaporation pond. Two concrete headwalls are installed in the trench and can be used to divert flow to the holding pond. These headwalls are also equipped with weirs so that the flow in the trench may be measured.

The evaporation pond is located on the southern edge of the site. It is approximately 300 ft square and between 3.3 and 5 ft deep with a design volume of about 3.4 million gal. The flow from the interceptor trench is collected in the evaporation pond where it can percolate into the ground.

The geology, soils, vegetation and wildlife, climate, and groundwater in the general area and at the site are discussed in Appendices A-E.

Two identical solution feed gas chlorinators, each with a maximum capacity of 300 lb of Cl_2 per day can be used to feed a solution of chlorine and plant water to the headworks, the sludge return lines, the spray pump suction line, the sludge holding tank and the chlorine contact tank. Each chlorinator is a standby for the other. Gas is provided in 150-lb cylinders. The chlorine contact tank, divided into two identical compartments, is 31 ft long by 24 ft wide with a sidewater depth of 7.5 ft and is designed to provide a 19-min contact time at the peak winter flow. There is a Parshall Flume for flow measurement immediately upstream of the chlorine contact chamber.

Chlorine solution feed rates can be manually or automatically set to feed in proportion to flow entering the chlorine contact tank. Automatic switching to mixed minimum feed rates for low flows is also possible. Normally one chlorinator is used to chlorinate the chlorine contact chamber, and the second is used to chlorinate other points in the system. A total feed rate is set, and Rotameters are used to proportion the chlorine flow to the desired application points.

OPERATIONS

Table IV shows the average daily flow to the facility during the months of March through December of 1976.

TABLE IV[1]. Average daily influent flow by month.

Month 1976	Average daily flow (gal. x 1000)
March	89.5
April	60.0
May	53.8
June	52.6
July	79.5
August	96.7
September	74.4
October	42.5
November	43.6
December	95.5

The average daily weekday flows and average daily weekend/holiday flows for November and December 1976 are:

	Weekday, gal. x 1000	Weekend/Holiday, gal. x 1000
November	33.3	56.9
December	67.6	132.6

These flow data are not useful for predicting future flows because throughout 1976 the number of connections to the collection system increased rapidly. However, the flow figures do show the large seasonal fluctuations in flow, as well as the difference between weekday and weekend flow. As of 27 December 1976, it was estimated that 91% of the expected 160 initial hookups to the system had been made.

The operator's records are the only source of data on the quality of the wastewater as it passes through the various unit processes of the treatment facility. A summary of BOD and suspended solids data is given in the following tables (V and VI).

TABLE V[7]. Biochemical oxygen demand, mg/l.

Date	Influent	Secondary process effluent
1 Mar 76	665*	30
17 Mar 76	246	16
19 Mar 76	170	17.1
9 Apr 76	91	26
24 Jun 76	127	9.0
22 Jul 76	134	8.9
19 Aug 76	136	18
14 Oct 76	86	2.9

*operator indicated problems with test procedure

TABLE VI[7]. Total suspended solids mg/l.

Sampling date	Plant influent	Secondary process effluent
8/ 9/76	170	3
8/16/76	78.3	3.6
8/25/76	166	6.5
8/30/76	80	7.3
9/ 9/76	186	5.8
9/13/76	110	3.8
9/20/76	114	6.5
9/23/76	236	4
9/27/76	88	6.8
10/ 8/76	228	10.5
10/13/76	440	3
10/21/76	192	1.5
10/27/76	100	8
11/ 2/76	168	28
11/10/76	90	16
11/19/76	80	22
11/29/76	69	2
11/30/76	130	16

Data from the State of Vermont Operations Report based on a visit to the site on 9 August 1976 are summarized in Table VII.

TABLE VII[6]. State of Vermont operations report.

	Plant influent	Secondary process effluent
pH	7	6.8
Temp °C	18	19
Dissolved oxygen, mg/l	6.0	4.9
Sus. Solids, mg/l	108	4.0
Sett. Solids, mg/l	7.0	T
BOD, mg/l	115	3.6
Kjel.-N, mg/l	14.7	1.5
Ammonia-N, mg/l	12.33	0.48
Nitrate-N, mg/l	16	5.64
Phosphate, mg/l	4.75	4.23
Fecal Coliform, Colonies/100 ml	--	0
Chlorine Residual, mg/l	--	0.6

The results of chemical analysis of groundwater samples taken from the observation wells in the spray field, the effluent spray, and water from the interceptor trench are shown in Table VIII.

TABLE VIII[7]. NBFD #1 observation wells - chemical analysis.

	29 October 1976 Wells			20 December 1976 Wells		Samples	
Parameter	1	2	3	2	3	4[1]	5[2]
pH	6.6	6.4	6.4	6.8	6.7	7.1	6.95
Alkalinity, mg/l	60	20	20	20	20	80	40
Hardness, mg/l	-	-	-	80	80	140	80
Sulfates, mg/l	2.0	0.0	0.0	T	11	12	T
Chloride, mg/l	40	40	40	20	60	80	80
Ammonia-N, mg/l	4	4	1.8	0.4	0.45	5	2
Nitrate-N, mg/l	2.5	5.0	4.6	-	-	-	-
Phosphate, mg/l	2.0	0.9	5.6	-	-	-	-

NOTES: 1. No water in well 4; sample is of effluent spray
2. No water in well 5; sample is from overflow weir in spray field interceptor trench

The plant's operation and maintenance manual[4] indicates that certain limitations should be observed in operating the spray system. These include:

1. Limiting the application rate of effluent to 2.5 in. per week. The maximum amount of effluent that can be sprayed in one week on the 34 acre spray area is 2.3 million gal.

2. Application rates should not exceed 0.25 in. per hour.

3. Spraying during periods of rain is prohibited.

4. Spraying when the ground is saturated with water, or when there is visible runoff from the spray site is prohibited.

5. Spraying during periods of high winds is prohibited.

The summer spray schedule for 1976 is shown in Table IX. Each spray pump normally sprayed one of four laterals for 15 minutes each hour until the total spray time in the schedule was achieved, or until the polishing pond was drawn down.

TABLE IX. Summer spray schedule[5].

Spray lateral	Required flow, GPM	No. of nozzles	Spray time, min.
1	87	10	90
2	105	13	90
3	142	17	90
4	148	18	90
5	161	20	90
6	161	20	90
7	148	18	90
8	161	20	90
9	167	21	90
10	161	20	90
11	161	20	90
12	210	26	90

High wastewater flows during the winter require maximum application under winter conditions. At the end of each spray cycle it is essential to rapidly drain the spray lateral before the nozzles and pipeline freeze. To accomplish this, Parasol 1/2 E40 nozzles, manufactured by Spraying Systems Co., were originally installed at the 66 low points. In operation, these nozzles drained the majority of the water from the line quickly, but some trickled out over a period of several hours. Progressive freezing of the the trickling water occurred at ambient temperatures as high as 27°F and liquid temperatures of 40°F. The water continued to move through the lateral on the next spray sequence, but could not drain at the end of the sequence and froze in the pipe. In addition the configuration

of the nozzle induced a centrifugal effect enabling silt to accumulate in the pipe, which eventually abraded the side of the nozzle. From these experiences, a modified Full Jet 3/4 HGW low-point nozzle was developed that has performed satisfactorily at air and liquid temperatures of -3°F and 40°F respectively. These modified low-point nozzles have performed well in the winter at this site.

The original high-point nozzles were found to be susceptible to freezing damage. The water in the pipe froze and required excessive maintenance probably due to the non-moving parts. Also, the Buckner spray diameter was significantly larger than the corridor cleared for each lateral, which may have resulted in excessive ice damage to the vegetation. Full Jet 1/4 HH14W nozzles, placed at 25-ft intervals, were selected for winter use to replace the original high-point nozzles. The Full Jet 1/4 HH14W high point nozzles sit flush on the laterals. Freezing spray forms a large cradle of ice on the laterals (see Figure 5) that the operator routinely removes to prevent damage to the them.

In April 1976 the engineer recommended that alternating between spray lines not be practiced during the winter months[8]. Therefore, the spray system was operated in that manner starting in October 1976 and through the winter. Now, based on additional experience, the engineer feels that winter operation on a sequencing basis should be attempted using a low end temperature limitation[1]. Operating experience indicates that spraying may be conducted as long as the ambient air temperature is 10°F or above[1].

Figure 5. Ice buildup on spray laterals.

APPENDIX A[1]. Geology

The Dover area lies on the eastern flank of the Green Mountain anticlinorium, an arched complex of folds. The Green Mountains were formed at the close of the Ordovician period about 425 million years ago. The anticlinorium consists of a central area of pre-Cambrian metamorphic rocks - gneisses, schists, quartzites, and lime-silicate granulites - mantled by a Lower Paleozoic sequence of volcanic rocks.

Only general information concerning the bedrock geology underlying the NBFD #1 facility is available and no specific geolgic data have been compiled for the treatment facility site. However, the spray site is underlain by two major formations: Wilmington Gneiss and the Hoosac Formation.

Wilmington Gneiss, which underlies the southwestern portion of the spray site, is composed mainly of coarse gray, buff, and pink microcline-augen gneiss, with smaller quantities of quartzites, schists, and calc-silicate granulite. This formation is of probable pre-Cambrian age.

The Hoosac Formation underlies the remainder of the spray site and consists mainly of medium to course-grained muscovite, chlorite, biotite, garnet, quartz schists, and interbedded amphibolites. Fossil evidence indicates a Lower Cambrian age. The Hoosac Formation ranges in thickness from 700-2000 ft.

Unconsolidated surficial material deposited during the Pleistocene Epoch overlies the bedrock. The Dover area experienced two glaciations, separated and followed by periods of post-glacial erosion and deposition. The Bennington Glacial Stade covered all New England and left behind surficial material known as Bennington Glacial Till. Bennington Till is sandy and silty with very little clay. It is often very hard and most fragmented material is derived from the parent bedrock.

The Shelburne Glacial Stade occurred later, and extended southward approximately to Dover, Vermont. This glacial episode left deposited material known as Shelburne Drift in a thin veneer over the bedrock. Shelburne Drift is predominantly an ablation till of loose sandy texture containing a high percentage of angular cobbles and boulders composed of local bedrock.

The surficial material covering the bedrock in the NBFD #1 area is very thin. Based on well drillers' records since 1966, depth to bedrock ranges from 2 to 32 ft in the vicinity of the treatment site. The water well supplying the treatment facility is drilled into the shale which lies 28 ft below the ground surface. Bedrock is closer to the surface in the spray field. However, several bedrock outcrops are visible on the upper slopes of the spray field.

APPENDIX B[1]. Soils

The soils of the Dover area have developed mainly from glacial till derived from granite, gneiss, schist, and shale. The predominant soils in the area are stony, sandy loams characterized by a low silt and clay content and low pH. Most of the area is underlain by a fragipan which restricts water movement to the ground water.

There is no site-specific soils information for the NBFD #1 Treatment Facility. Generalized soils information for the Town of Dover is available from the General Soil Map for Windham County, prepared by the Soil Conservation Service[9]. Two soil associations are found on the site of the treatment plant.

1) Unadilla-Windsor-Merrimac Association.

   Deep, gently sloping to sloping, silty and sandy soils low to medium in lime; on dissected terraces and lake plains along rivers and brooks.

2) Peru-Cabot-Muck Association.

   Deep, level to sloping, moderately well drained to poorly drained, loamy and organic muck and packed soils low in lime and with a hardpan within 3 ft; in depressions and on wet sideslopes.

In 1972, more detailed soil surveys were prepared by the SCS in some areas of Dover, including the spray site[10].

The predominant soil type in the spray field is Peru/18. This soil is moderately well drained, and has a compacted glacial till layer (fragipan) that occurs from 15 to 30 in. below the surface. The density and texture of this fragipan layer is variable. Permeability of the soil above the fragipan is high in comparison to the permeability of the fragipan. Depth to seasonal high water table is 1.5 to 2 ft; however, a continuous saturated condition exists above the fragipan during wet seasons. Depth to bedrock is 4 to 10 ft or more. The dominant slope of the spray area on the east side is from 8% to 15%. The west side of the spray area has a slope greater than 25%.

The soils located in the spray area, along the North Branch are classified as Windsor/14 gravelly subsoil series. These soils are well drained and have developed from a sand that extends to a depth of about 23 in. Below 23 in. the soil material is coarse sand and gravel. The permeability of the soil is rapid to very rapid. Depth to water table and bedrock typically is 3 to 5 ft or more.

Depressions and natural drainage ways occur within the spray field that are poorly drained. There are also some areas that are well drained. Significant bedrock outcroppings are visible on the north and south ends of the area, but few outcrops are found within the spray site.

The plant site was formerly a gravel pit. Prior to construction, groundwater was observed seeping from the bedrock or standing in small depressions along the western side of the area. Originally, the small areas of undisturbed soil within the plant site were mapped as Windsor subsoil, gravelly variant.

In the flood plain along Ellis Brook well-drained Podunk/24 soil was mapped. This soil consists of a sandy loam material 28 to 36 in. deep. The permeability of this sandy loam is moderately rapid. Depth to seasonal water table is 1.5 to 2.5 ft and depth to bedrock is typically greater than 5 ft.

The origin and distribution of the fragipan underlying the Peru soils on the spray site are unknown. A typical profile of the Peru soil is shown in Figure B1. Fragipan type 1 is the most common form in accurately mapped Peru soils. Fragipan type 2 is less common, while type 3 is poorly defined and occurs only in special cases of Peru soils.

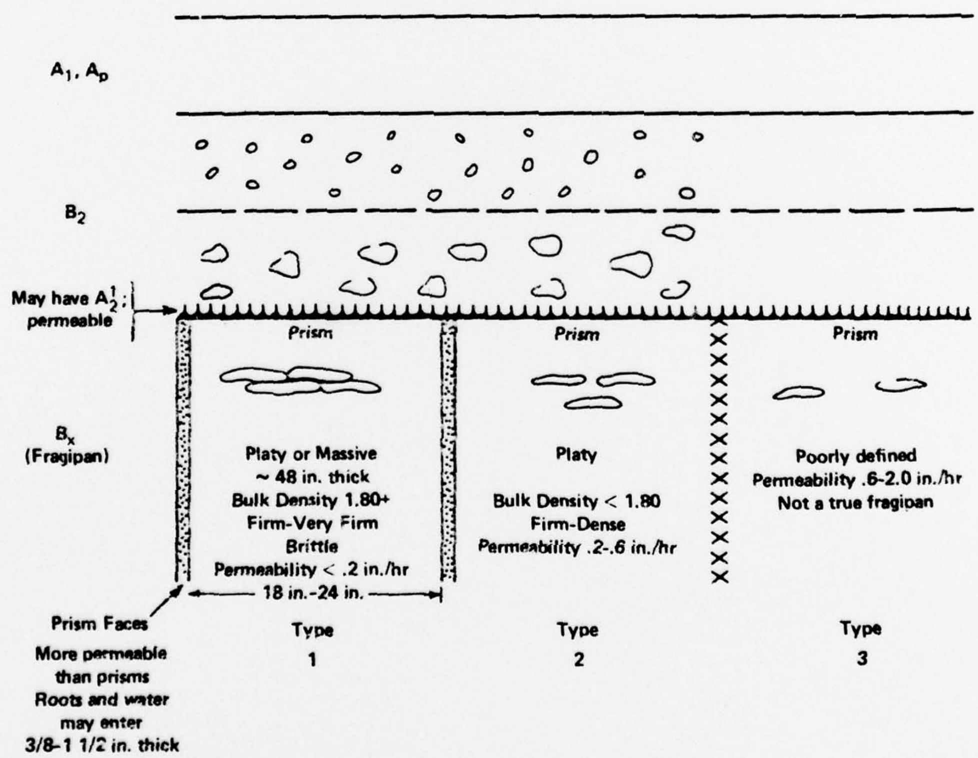

Figure B1. Typical profile of Peru soils.

The distribution and thickness of the fragipan layer in the spray field has not been defined. However, some generalizations appear possible. Fragipan types 1 and 2 are more common on slopes of less than 25%. On slopes greater than 25%, type 3 (not a true fragipan) is far more common. Thus it may be that the east slope of the spray field has a well defined fragipan layer, while the west slope draining toward the North Branch may lack this impermeable layer.

The characteristics of Peru soils may have significant implications for the spray site. The fragipan underlying the topsoil impedes the downwards percolation of water which could be reflected in prolonged saturated periods in the soil. This impermeable layer may divert the percolating effluent to lateral subsurface flow over the top of the fragipan. Thus, the sprayed effluent would tend to flow out of the spray field more rapidly than if the soil strata were deeper and lacked a fragipan.

APPENDIX C. Vegetation and Wildlife

There are no site-specific data on vegetation or wildlife for the treatment facility. About 90% of the spray field is forested. Approximately 40% of the spray area, primarily the eastern slope of the knoll, is forested with species of the Northern Hardwoods - maples, beeches, and birches. The understory consists of a fairly dense stand of balsam, spruce, and hemlock. Part of the hillside was at one time a sugarbush, as evidenced by light stands of 8-16-in. sugar maples. Some areas of the spray field are extensively populated by blackberry bushes, particularly near the base of the eastern slope.

More than half the forested area of the spray field is dominated by conifers - white spruce, spruce, and fir - primarily along the crest and western slope of the knoll. These species dominate in the areas of thinnest, most acid soils which are subject to the most extreme microclimates. There are no quantitative data concerning species distribution. Trees and other vegetation were cleared from an area of 10-20 ft in width during construction for placement of the spray lines.

The results of spraying in sub-freezing weather near trees are readily visible. The spray freezes to the lower branches of conifers and young hardwoods and blankets other vegetation with an ice covering (Figure C1). The long-term effects of this ice covering on the vegetation are not known.

Figure C1. Ice accumulation on vegetation at the West Dover land treatment plant.

The only information concerning wildlife is drawn from reports of local residents. Prior to construction, the area was often frequented by deer, although it was not regarded as a deeryard. In past years, a sizable fox population was noted in the area of the spray field. A five-foot chain-link fence now surrounds the entire spray field and presents a major barrier to animal life in the area. Deer apparently use the area as a sanctuary of sorts from local dogs since, in the spring, deer can jump the fence while dogs are prevented from jumping or digging under.

APPENDIX D. Climate

Because of its elevation and location east of the peaks of the Green Mountains, the Dover area experiences a climate similar to that of extreme northern Vermont. Adiabatic cooling of air masses rising across the Green Mountains causes high precipitation with the annual precipitation averaging about 55 in. Although snowfall averages over 100 in. annually, 170 in. of snow fell in 1972.

Mean annual temperature for the Dover area is about 40-45°F. Frost-free periods average 60 to 90 days. The first fall freeze generally occurs in the last half of September and the last spring frost usually occurs in late May.

There are no compiled data for wind direction and velocity in the area. However, local observations suggest that the prevailing winds are from the northwest in winter and west or southwest in summer. Consequently in winter, exposure is likely to be maximum on west facing slopes and minimum on east facing slopes.

Weather data specifically applicable to the Treatment Facility site are available from a resident of West Dover who lives about 0.5 mile north of the site. She has collected precipitation, temperature, wind direction, and water equivalence of snow data for the National Weather Service River District Office in Albany, New York, since 1958. Unfortunately, no means, normals, or summaries have been derived for those data by the NWS.

APPENDIX E. Groundwater

Although no detailed groundwater investigations have been conducted in or near the spray site, available general information indicates that the treatment facility is located in an area of significant groundwater activity. The Wilmington gneiss underlying part of the spray site tends to be extensively fractured and thus of high groundwater potential. The existence of a major gravel deposit is a potential source for containment of groundwater. The North Branch and Ellis Brook may contribute to groundwater recharge. The spray site may also contribute to the flow of the North Branch from the west slope of the spray field or to Ellis Brook through the gravel underlying the plant site.

Studies by the U.S. Geological Survey and the Vermont Department of Water Resources on groundwater favorability suggest that the area near the western boundary of the treatment facility property along the North Branch is an area of moderate groundwater potential[12]. This area is underlain by relatively thin deposits of coarse-grained stratified glacial drift and stream gravel. It is deemed suitable for shallow wells and infiltration galleries that should yield sufficient quantities of water for domestic, commercial, and light industrial use.

On-site observations support indications of significant groundwater activity. Subsurface water was frequently encountered during construction of the treatment facilities, particularly near the oxidation canals and in the holding pond. Several natural springs have been observed on the east slope of the spray field. Plant personnel observed water flowing in the spray field interceptor trench even before initiation of spraying.

High groundwater conditions exist in the spray field during the period of snow melt usually for no more than 4 weeks. However, the characteristics of Peru soils suggest a fairly shallow groundwater table, 1.5-2.5 ft below the surface.

According to information from the Vermont Department of Water Resources, 15 domestic water wells have been drilled near the facility since 1966. Depths of the wells range from 100 ft to 700 ft, with a median depth of 200 ft. Reported water yields range from 0.5 gpm to 50 gpm with a median yield of 4 gpm. Wells with particularly high yields seem to be clustered around the facility site. The water well for the plant was drilled in March 1975 to a depth of 155 ft yielding 30 gpm. In the context of regional and local water wells, this is a high yield. Little water quality data exists for the wells. Since 1975, 12 samples from the treatment plant's well have been sent to the Vermont Department of Health for bacteriological analysis. All samples showed no detectable coliform bacteria.

Information is not available to determine the direction of groundwater movement or recharge to streams in the site area. It is apparent that groundwater is flowing from the knoll where the spray field is located. Soil types along the North Branch and along Ellis Brook seem conducive to groundwater movement. A more detailed investigation of groundwater activity in and around the spray site is needed.

Six observation wells are located just beyond the limits of the spray field. All of the wells consist of 4-in. diam. perforated PVC pipes which extend down to the fragipan. The wells were initially located in abritrary "stategic" areas and more accurately located after field investigation had been completed.

Two of the six observation wells have been dry since their installation. The others have been sampled for analysis twice since operation began. These data are presented in Table VIII. Note that samples 4 and 5 on 20 December 1976 consisted of effluent spray and overflow from the weir, not groundwater.

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